Space Weather Technical Forecast

Issued on Saturday, 25 March 2023 at 00:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Minor/Moderate Geomagnetic Storms likely with a slight chance of Strong storms on Day 1 (25 Mar), then declining. Chance of R1/R2 Radio Blackouts. Active fluence becoming likely by Days 3-4 (27-28 Mar).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been low over the past 24 hours with occasional minor C-class flares. There are currently eight sunspot regions on the visible disc. AR3256 in the southwest quadrant remains the largest and most complex region on the disc, with some growth in the penumbral area of the trailing spots. AR3260 near north centre disc shows more of a north-south magnetic alignment, which may increase magnetic instability. Both AR3259 in the southeast and AR3258 in the northwest have shown some minor growth in recent hours. The other regions appear to be mostly stable at present with limited size and magnetic complexity.
No Earth directed CMEs are currently forecast.

Solar Wind / Geomagnetic Activity: The solar wind as measured at L1 by DSCOVR, has shown waning CME effects, with a possible onset of the HSS from CH86. Wind speeds have been slightly elevated, varying between 400-500 km/s. Density was initially above average with a peak of 35 ppcc at 24/0730 UTC, before decreasing after 24/0920 UTC to mainly average. The IMF was initially strong with a peak of 20nT, but became mostly moderate from 24/0600 UTC. The north-south component started strongly negative with a peak of -16nT, but gradually became mostly weakly negative after 24/0730 UTC. The phi angle started positive (away from the Sun), but gradually switched to negative (towards the Sun).
Geomagnetic activity was initially G3/Strong (Kp7), with a G4/Severe storm (Kp8) interval observed 24/0300-0600 UTC. Since then activity has gradually declined to be mostly Unsettled to G1/Minor storm (Kp3-5).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. The high energy electron flux (greater than 2MeV) has been at mostly background levels. The associated 24-hour fluence remained below the Active (1e8 integrated pfu) threshold, with a declining trend. At 25/0000UTC the observed fluence was 1.53e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is most likely to remain low, but with a chance of becoming moderate with any isolated M-class flares. The main region likely to give higher flares is AR3256 in the southwest.

Solar Wind / Geomagnetic Activity: The arrival of two CMEs that left the Sun on 20 Mar are the most likely cause of the enhanced geomagnetic activity that commenced on 23 Mar. Effects from these CMEs are now waning, with no further Earth directed CMEs currently forecast. The HSS from CH86/- is likely to have started to arrive at Earth, although the ongoing CME effects are swamping this signal to some extent. Wind speeds are likely to be at elevated levels around 500-550km/s with this feature, albeit with some uncertainty. Currently, it is considered most likely that elevated wind

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speeds will continue through the next couple of days with a slow decline thereafter. Geomagnetic activity is forecast to remain enhanced at first with G1-G2/Minor-Moderate storms likely, with just a slight chance of further G3/Strong storms on Day 1 (25 Mar). As the CME and then HSS effects wane geomagnetic activity is expected to slowly ease, likely becoming mostly Quiet by Day 4 (28 Mar).

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to remain at background levels, but with a slight chance of reaching S1 or greater, should any significant flares occur. The high energy (greater than 2 MeV) electron flux is currently at background levels due to recent CME effects, but is likely to rise through the period. The associated 24-hour fluence is expected is also expected to rise, with Active (1e8 integrated pfu) conditions becoming likely by Days 3-4 (27-28 Mar).

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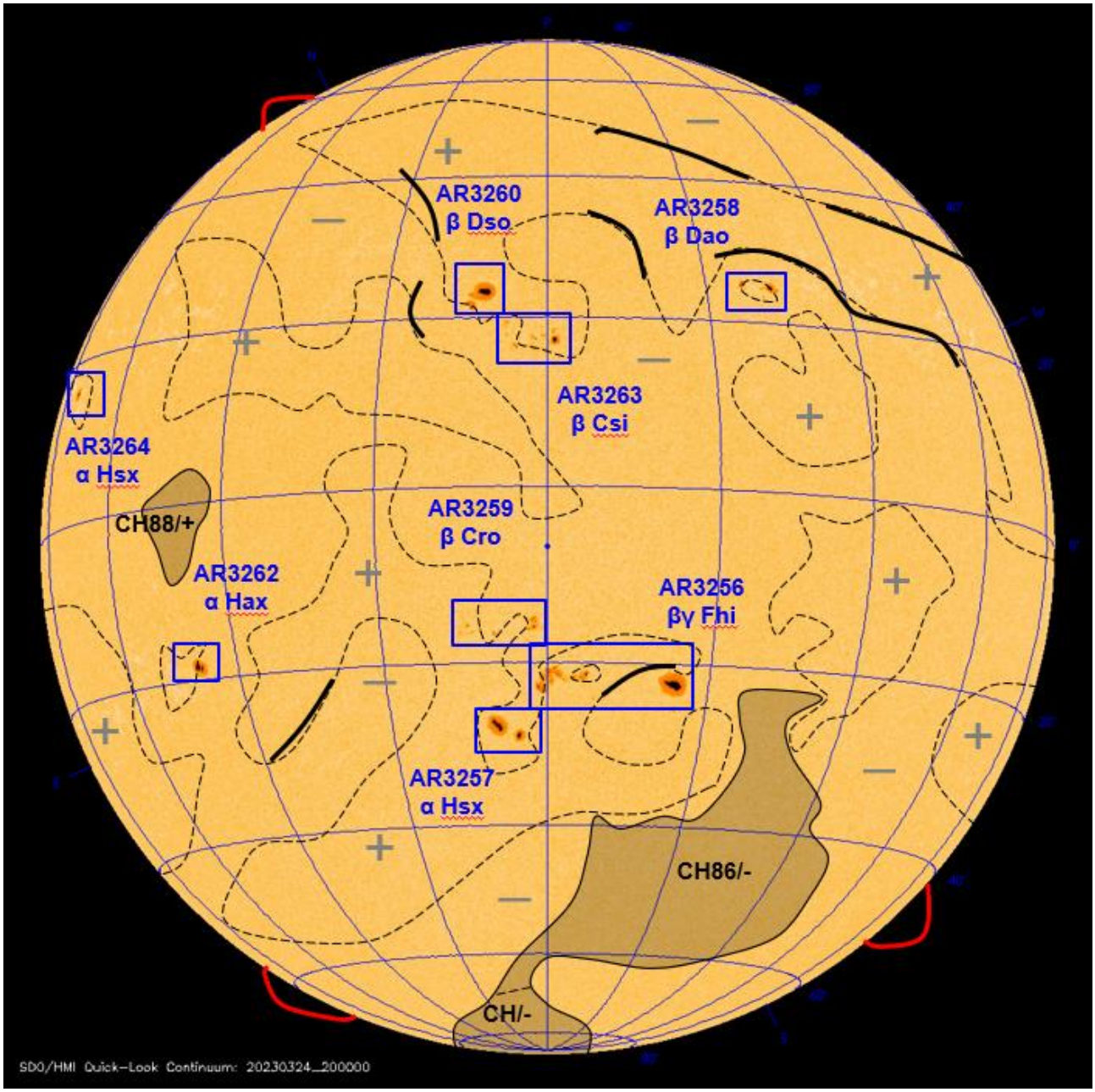
Figure 1. Solar Analysis Valid 24/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

The arrival of two CMEs that left the Sun on 20 Mar are the most likely cause of the enhanced geomagnetic activity that commenced on 23 Mar. Effects from these CMEs are now waning, with no further Earth directed CMEs currently forecast.

The HSS from CH86/- is likely to have started to arrive at Earth, although the ongoing CME effects are swamping this signal to some extent. The solar wind trace at STEREO-A suggests that wind speeds are likely to be at elevated levels around 500-550km/s with this feature, albeit with some uncertainty. Persistence is not a helpful guide as there were significant CME effects on the previous rotation, and the coronal hole is much changed even in the last few days. The negative polarity of CH86 may also have a greater impact, due to the proximity to the spring equinox as per Russell-McPherron theory. Currently, it is considered most likely that elevated wind speeds will continue through the next couple of days with a slow decline thereafter.

Geomagnetic activity is forecast to remain enhanced at first with G1-G2/Minor-Moderate storms likely, and a slight chance of further G3/Strong storms on Day 1 (25 Mar). As the CME and then HSS effects wane geomagnetic activity is expected to slowly ease, likely becoming mostly Quiet by Day 4 (28 Mar).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	30	10	1
Strong	G3	Yes	10	1	1	1
Severe	G4	Yes	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
*	*	*	*	*	*	*

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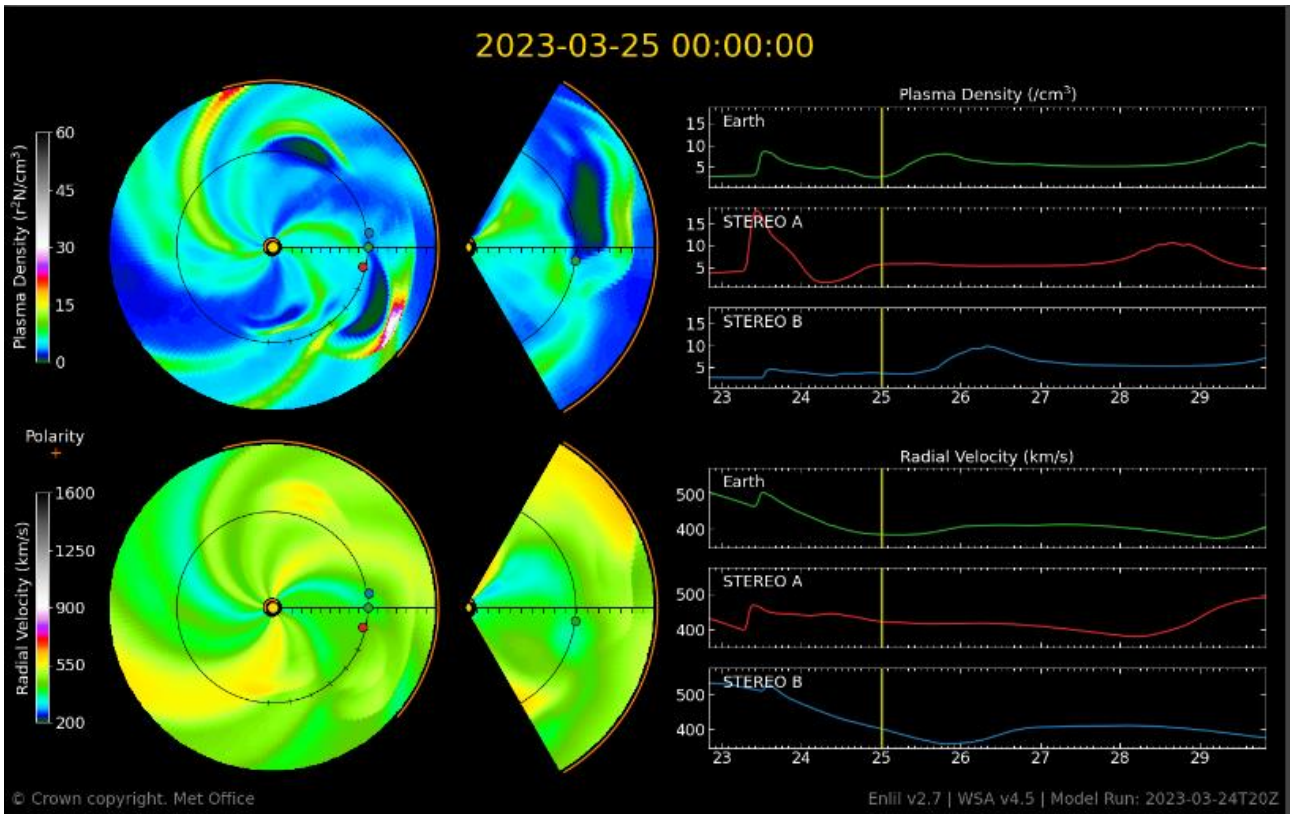
Figure 2: MOSWOC Enlil has not captured the current HSS from CH86. Wind speeds are likely to remain elevated, above Enlil's forecast, for the next couple of days before declining later in the period.



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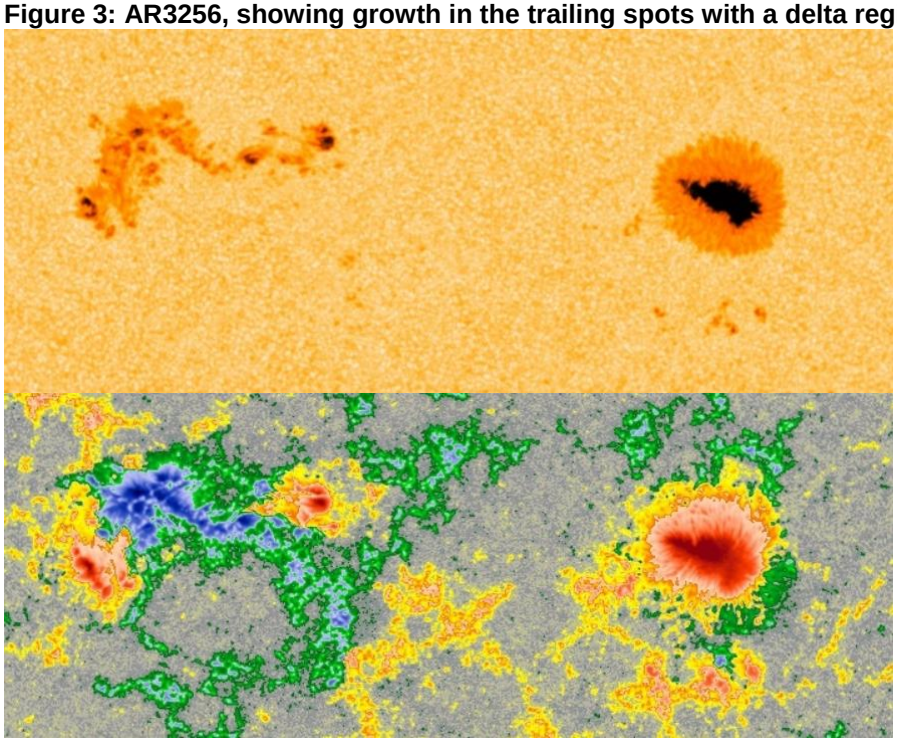
Radio Blackouts - X-Ray Flares:
There are currently eight sunspot regions on the visible disc. AR3256 now in the southwest quadrant remains the largest and most complex region on the disc. There has been growth in the penumbral area of the trailing spots, with signs it might be developing a delta region. AR3260 also shows more of a north-south magnetic alignment, perhaps increasing magnetic instability. Both AR3259 in the southeast and AR3258 in the northwest have shown some minor growth in recent hours. The other regions appear to be more stable at present with limited size and magnetic complexity.

STEREO imagery and the Carrington locations for up to three returning groups suggest that there are more regions to rotate onto the disc in the coming days, and so the risk of significant flares may increase later in the period if and when they rotate onto the visible disc.
Solar activity is most likely to be low through this period, but with a chance of moderate activity. This is mainly due to AR3256.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: AR3256, showing growth in the trailing spots with a delta region potentially forming.



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Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV), as observed by GOES16 is currently at background levels. Proton flux is most likely to remain at background levels, but with a slight chance of reaching S1 or greater should any larger flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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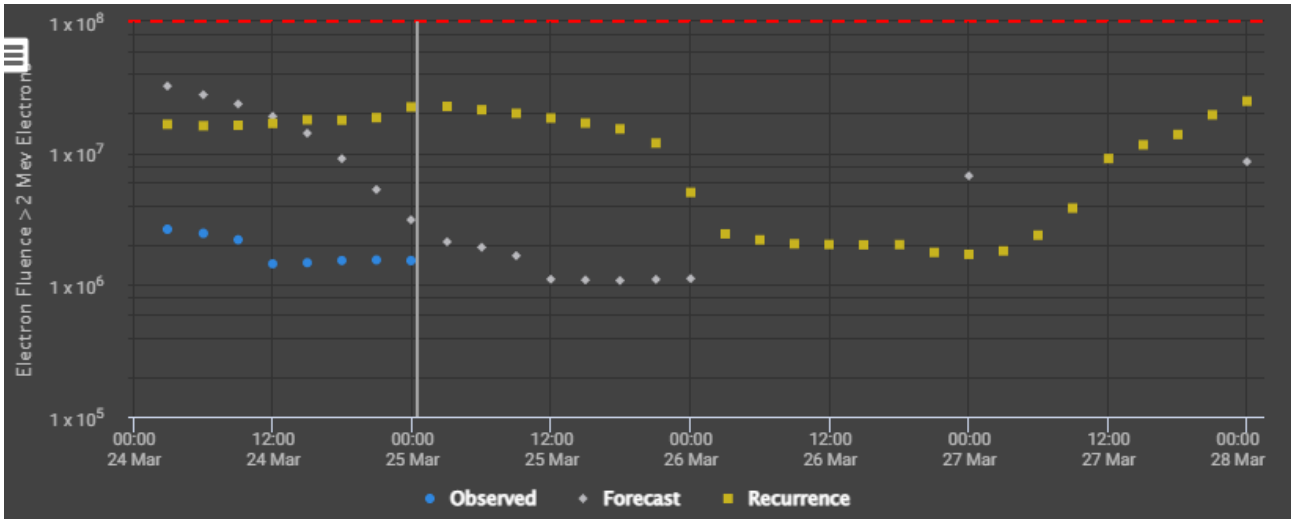
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux is currently at mostly background levels due to suppression by recent geomagnetic activity. We are also starting to see effects from the anticipated HSS from CH86, which is likely to continue the suppression with radiation belt compression through at least Day 1 and probably into Day 2 (25-26 Mar). Thereafter it is considered likely that the HSS and possibly the recent CME effects will have caused electron charging, with an increase in flux levels expected through the coming days as the HSS starts to wane. It is probable that flux will reach high levels at the diurnal maxima towards the end of the period, with moderate confidence.

The associated 24-hour fluence is also expected to rise through this period, with Active (1e8 integrated pfu) conditions becoming likely later in the period. MOSWOC REFM is suggesting a rise below Active by Day 3 (27 Mar), which is a good trend although possibly a little low.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	30	50	60
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing an increasing trend in fluence, below the Active (1e8 integrated pfu) threshold. This seems like a good trend but may be too low.



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